中国航发湖南动力机械研究所
AECC HUNAN AVIATION POWERPLANT RESEARCH INSTITUTE

HYDROGEN AERO-ENGINE DEVELOPMENT: STATUS AND OUTLOOK

Nov. 2026

ICGA2026

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01

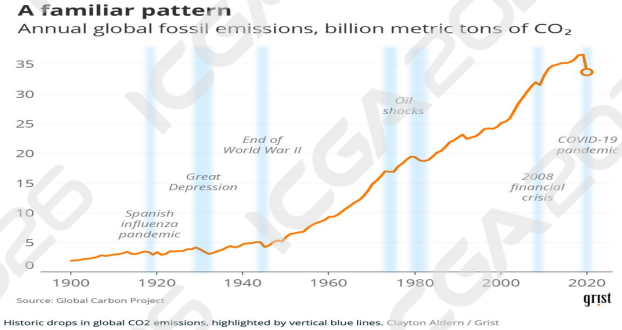
BACKGROUND

1. BACKGROUND

① GLOBAL SITUATION

Developing low-carbon green lifestyle has become a global consensus.

- In 2021, the carbon dioxide released by human energy consumptions has exceeded 36.3 billion tons.
- In 2022, the amount of CO_2 in atmosphere has risen to 419 ppm, reaching the peak value in past 4.5 million years.



The United Nations Framework Convention on Climate Change — 1992

Kyoto Pratocol — 2005

Copenhagen Accord — 2009

Paris Agreement — 2015

Climate Ambition Summit — 2020

1. BACKGROUND

② CARBON TRADE

The aviation carbon trade in China is poised to take off

Carbon trade in European Union

- **In 2012, aviation industry is officially incorporated into carbon trade market in European Union (EU).**
- **In 2023, the carbon trade amount in EU surpassed 770 billion Euro.**

Carbon trade in China

- **In 2021, China's carbon trade market officially launched.**
- **In 2024, Civil Aviation Administration of China initiated the entry of aviation industry into national carbon trade market.**



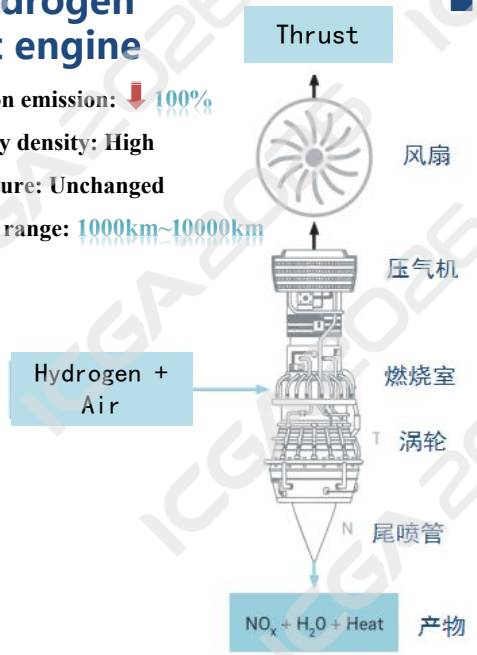
1. BACKGROUND

③ Aero-engine by clean energy

Hydrogen jet engine is the most promising path towards carbon-neutral for aviation industry

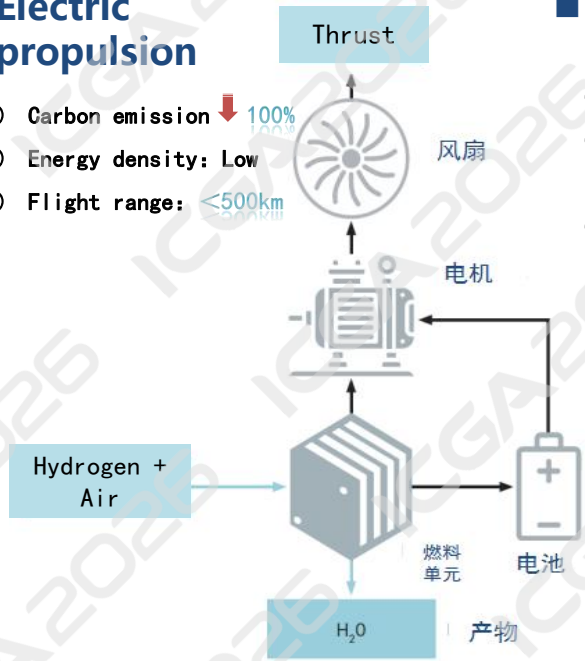
■ Hydrogen Jet engine

① Carbon emission: ↓ 100%
② Energy density: High
③ Structure: Unchanged
④ Flight range: 1000km~10000km



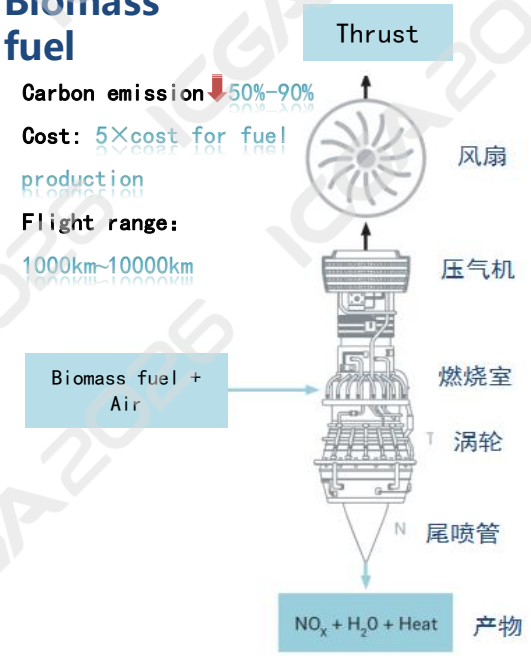
■ Electric propulsion

① Carbon emission ↓ 100%
② Energy density: Low
③ Flight range: <500km



■ Biomass fuel

① Carbon emission ↓ 50%~90%
② Cost: 5×cost for fuel production
③ Flight range: 1000km~10000km



02

CURRENT STATUS

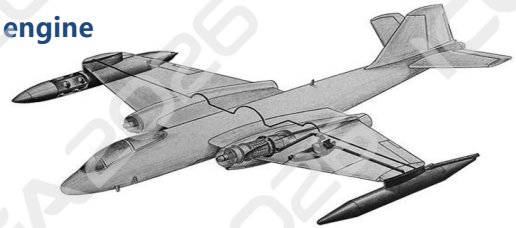
2 .Current status

① USA

US is the first country to develop hydrogen fuel aviation technology since 1950s, and has carried out a series of green aviation projects such as CLEEN, NextGen, ERA, and X-57. In Nov. 2020, U.S. Department of Energy released its Hydrogen Program Plan to provide a strategic framework for hydrogen research, development and demonstration activities.

Past

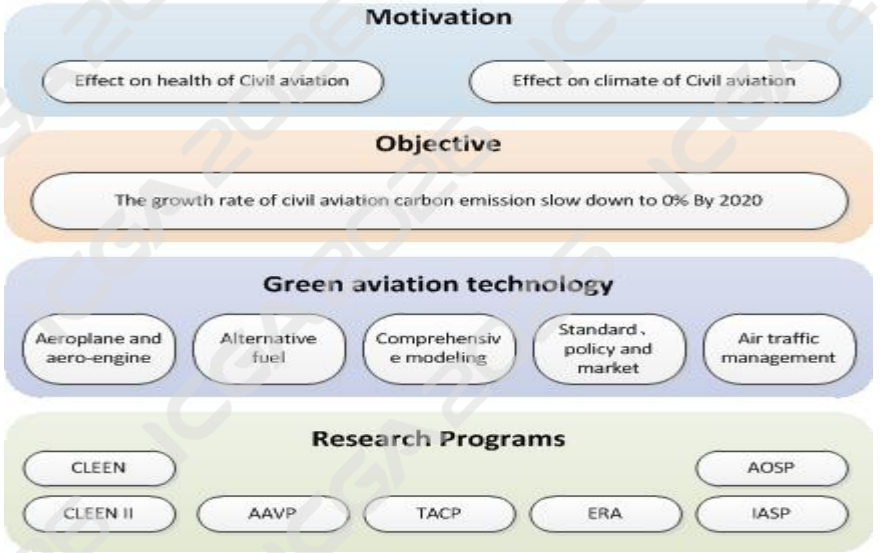
- 1957, B-57B bomber, powered by hydrogen jet engine



- 2020, Zero Avio, world's first manned hydrogen powered commercial aircraft



Now



Series of plans of U.S. on green aviation

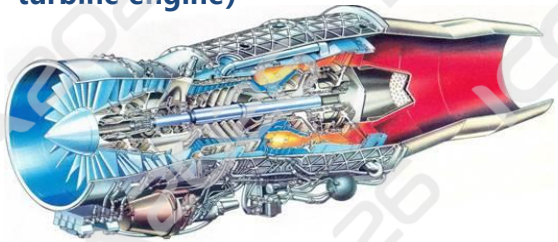
2 .Current status

② Europe

The Hydrogen-powered Aviation by 2050 published by the European Union shows that, current hydrogen fuel cells are suitable for short-haul aviation while hydrogen turbine engines can be used for medium and long-range flights, and hydrogen-powered aviation may enter commercial service by 2035 at the latest.

Past

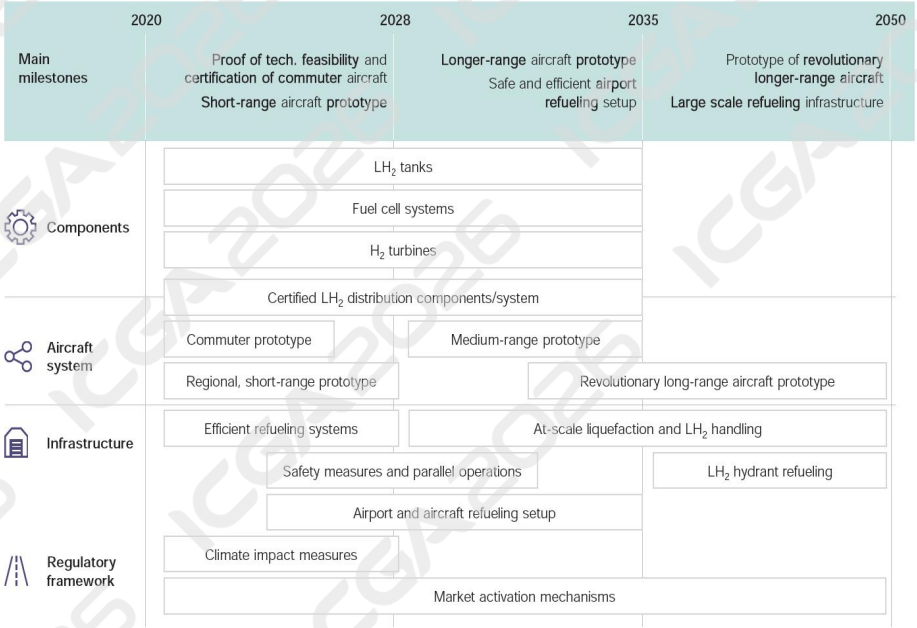
- 1990s, Rolls & Royce, EJ200 (Hydrogen turbine engine)



- 2020, Airbus, ZEROe Concept (powered by hydrogen)



Now



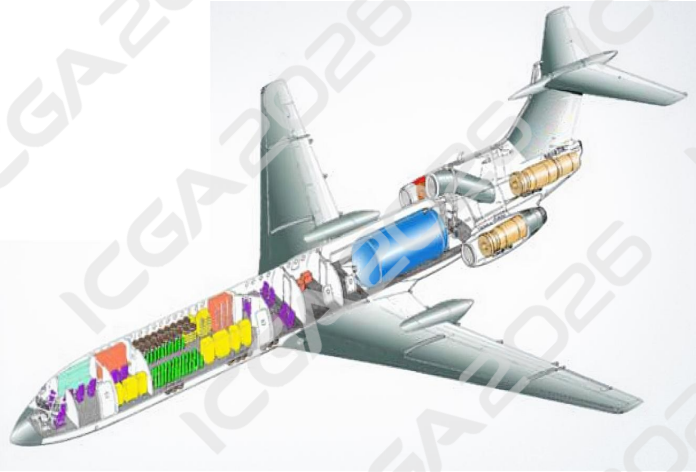
European Union: *Hydrogen-powered Aviation by 2050*

2 . Current status

③ Russia

In 1980s, Russia carried out a large number of flight studies on liquid hydrogen (LH2) fueled Tu155 aircraft. Though the project was eventually terminated, it has demonstrated that all systems of LH2 fueled Tu155 worked normally during flight tests with no engine shut-down in the air.

- 1988, Tu155 (LH_2 fueled aircraft, 164-passenger), Soviet Union.





2 .Current status

④ China

China has established an embryonic hydrogen industry chain which includes production, storage, transportation, refueling and application of hydrogen. However, the technology and market for hydrogen powered aviation are under development. the technology innovation and infrastructures are required for the hydrogen application in the aviation industry.

Hydrogen Industry Chain of China

Hydrogen Production

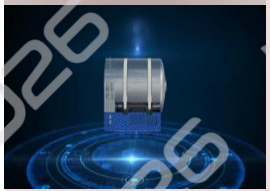
- Green hydrogen production



- Coal
- Water
- Nature gas
- Industrial byproduct
- Hydrogen purification
- Hydrogen liquidation

Hydrogen Storage and Transportation

- Hydrogen storage device



- Gaseous hydrogen
- Liquid hydrogen
- Solid hydrogen
- Liquid hydrogen Transportation
- Gaseous hydrogen Transportation

Hydrogen refueling and application

- Hydrogen Aviation



- Hydrogen fuel cell vehicle
- Power generation
- Heat supply
- Hydrogen refueling station
- Hydrogen refueling device

03

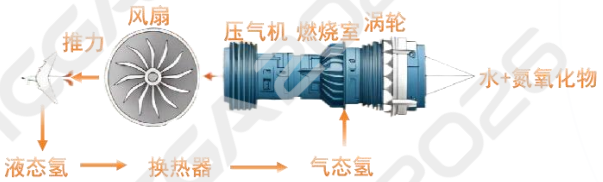
TECHNICAL CHALLENGE

3.Technical Challenge

① Major challenge of Hydrogen Turbine Engine

Hydrogen aircraft-engine integration、storage、control、combustion and safety are the major challenges of hydrogen turbine engine

Hydrogen Aircraft-engine Integration



Hydrogen Safe



Hydrogen Storage



Hydrogen Control



Hydrogen Combustion

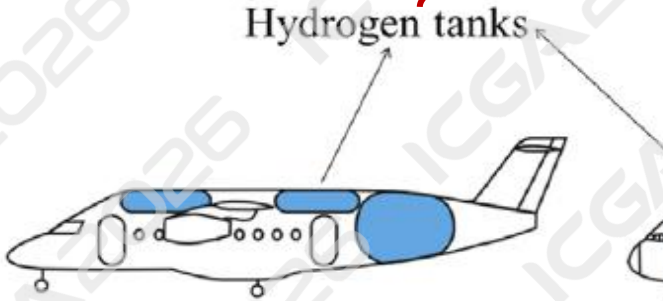


3.Technical Challenge

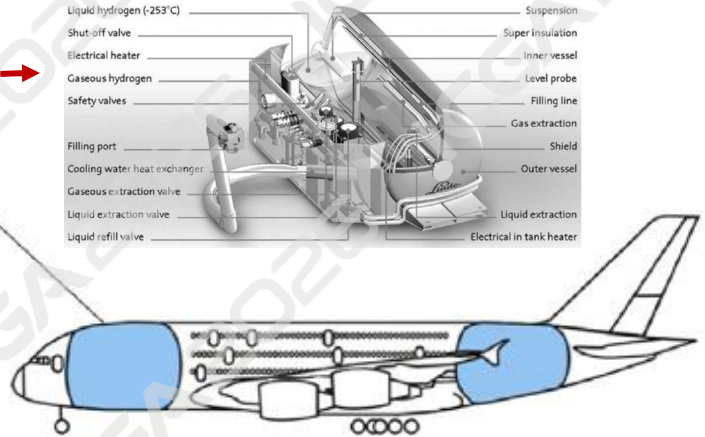
② Hydrogen aircraft-engine integration

The delivery of hydrogen fuel from tank to engine involves liquid hydrogen-supercritical hydrogen-gaseous hydrogen transformation, which results in closely coupling between aircraft fuselage, liquid hydrogen storage and transportation system and engine. Therefore, tranditional design methodology of aircraft-engine integration is inapplicable.





Medium-range aircraft

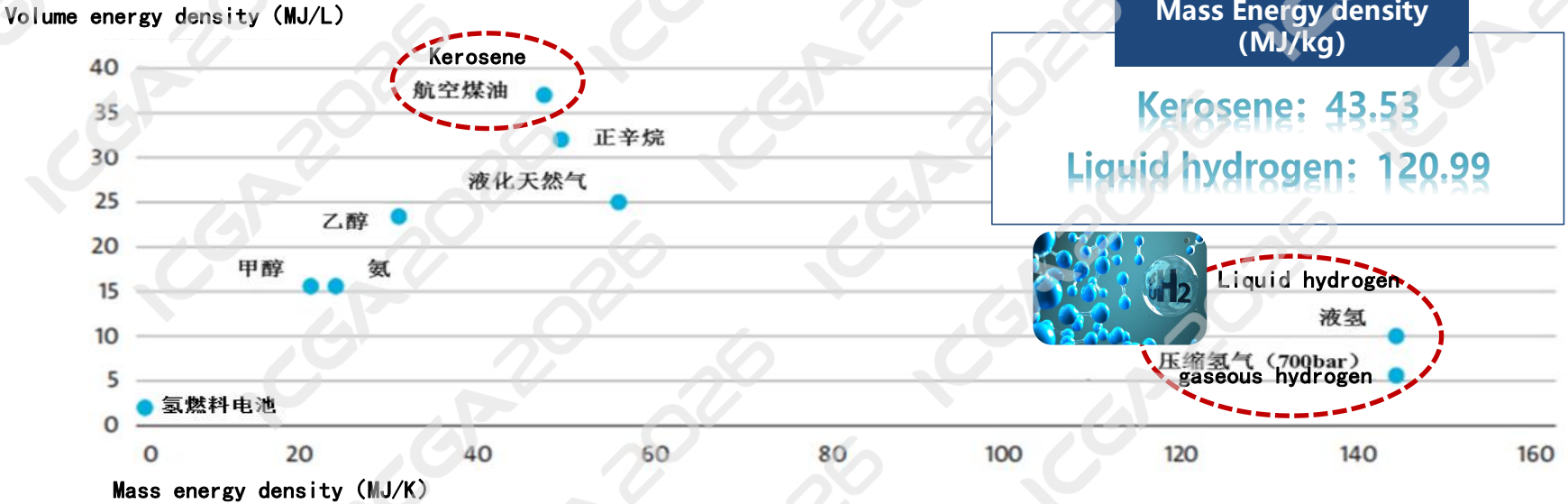


Long-range aircraft

3.Technical Challenge

③ Hydrogen Storage

The mass energy density of liquid hydrogen is 3 times than of kerosene, but its volume energy density is only 1/11 of kerosene. Therefore, the fuel tank volume of hydrogen-powered aircraft will be 3~4 times higher than that of traditional aircraft.



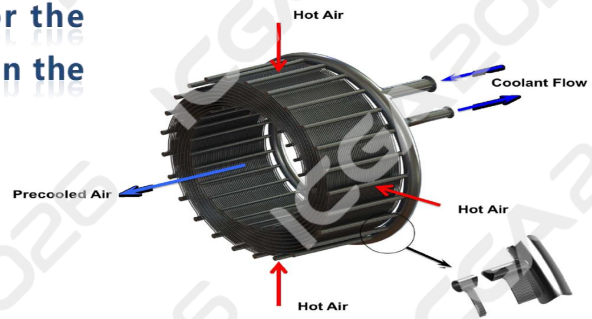
3.Technical Challenge

④ Hydrogen control

Since the boiling point of liquid hydrogen is -253°C, the temperature difference between the hot and cold sides of the heat exchanger is large, causing it to undergo a drastic phase change during the heat exchange process:

- Once the liquid hydrogen is not completely vaporized into hydrogen and forms a gas-liquid two-phase flow, it is easy for the hydrogen to reach a critical velocity in the pipeline and cause pipeline congestion.





Heat exchanger

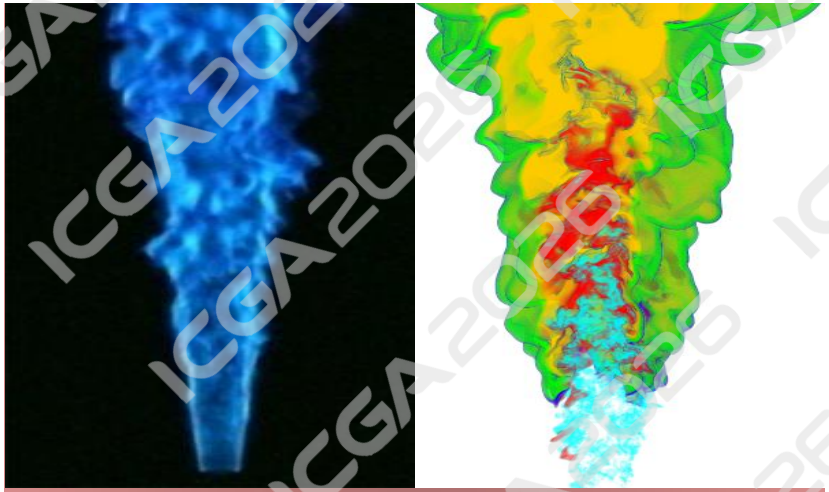


- The outlet pressure of the heat exchanger is prone to violent fluctuations, which affects the flow adjustment of hydrogen;

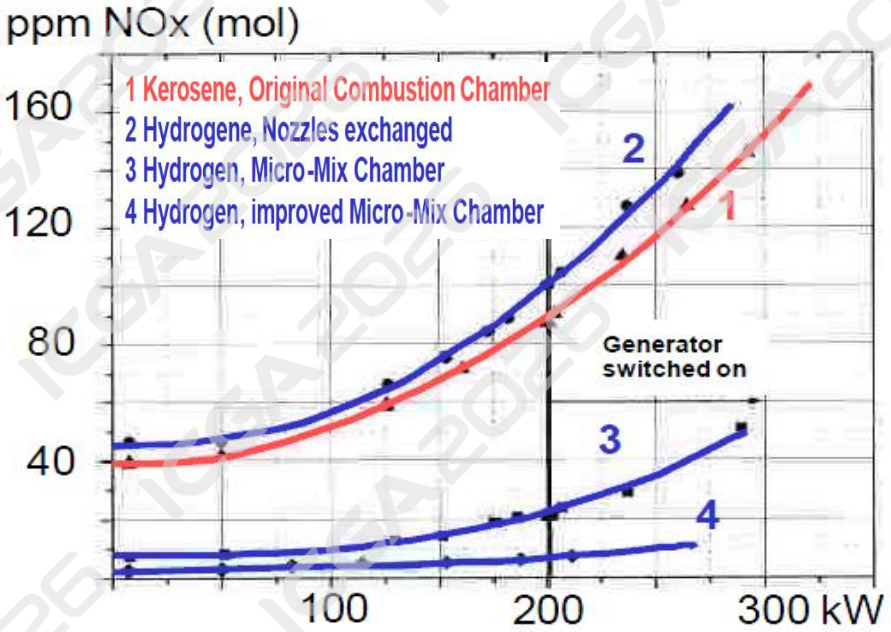
3.Technical Challenge

⑤ Hydrogen combustion: NOx emissions

The flame temperature of hydrogen is 10% higher than kerosene flame temperature, leading to higher NOx emissions of the combustor.



氢气射流火焰/Hydrogen jet flame



3.Technical Challenge

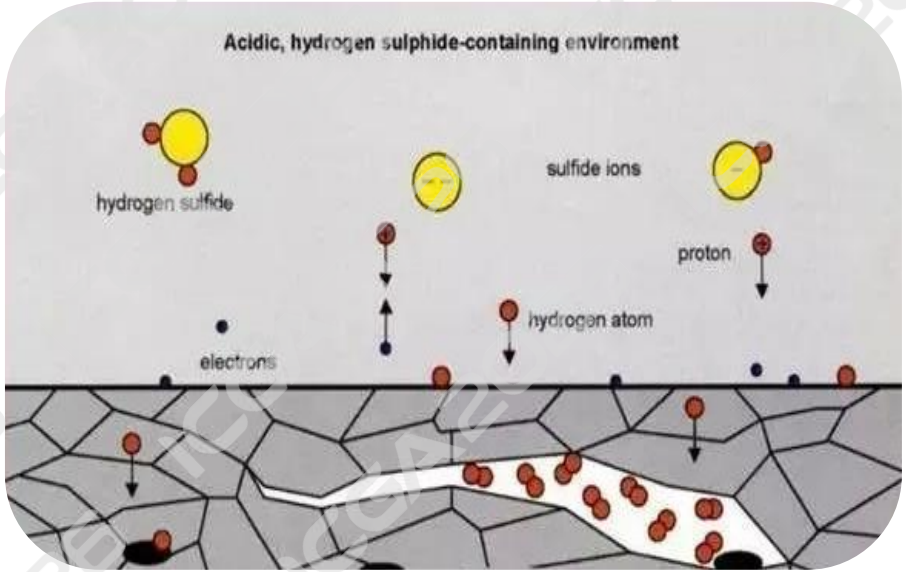
⑥ Hydrogen safety

The hydrogen atom is unstable and spread quickly inside the material, the development of hydrogen energy is severely hindered by the hydrogen embrittlement of metal materials.

- Hydrogen embrittlement : refers to the decrease in the plasticity and toughness of metals due to the hydrogen atom propagation.



Hydrogen induced crack



04

R&D REQUIREMENTS

4 . R&D requirements

① Integrated design of hydrogen aircraft/engine

H_2 storage and delivery integration

- Hydrogen delivery system
- Dry-type wing and propulsion system
- Fuselage and hydrogen tank

Thermal management integration

- Liquid hydrogen evaporation
- Engine turbine cooling
- Aircraft onboard system cooling

Control system integration

- Liquid hydrogen delivery control
- Engine and tank control
- Hydrogen safe control



4 . R&D requirements

② High density hydrogen storage

With the highest mass fraction, Liquid hydrogen storage is the most promising hydrogen storage technology in the future.

Hydrogen Storage

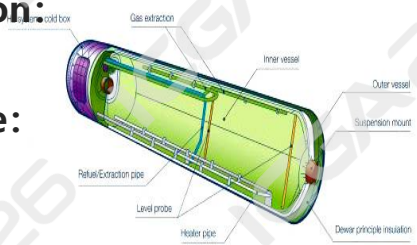
Gasous hydrogen

- Fuel mass fraction: 5%~8%
- Storage pressure: 70Mpa
- Maturity: TRL6



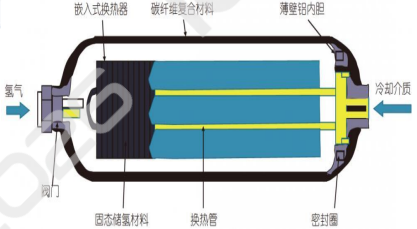
Liquid hydrogen

- Fuel mass fraction: 20%~40%
- Storage pressure: 0.14Mpa
- Maturity: TRL4



solid-state hydrogen

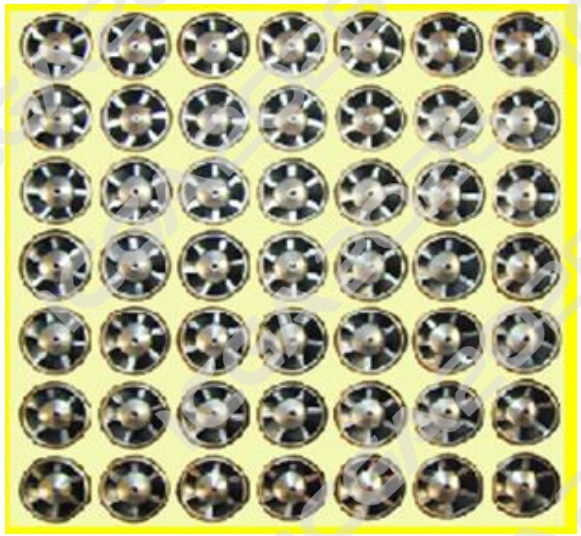
- Fuel mass fraction: 4%~6%
- Maturity: TRL4



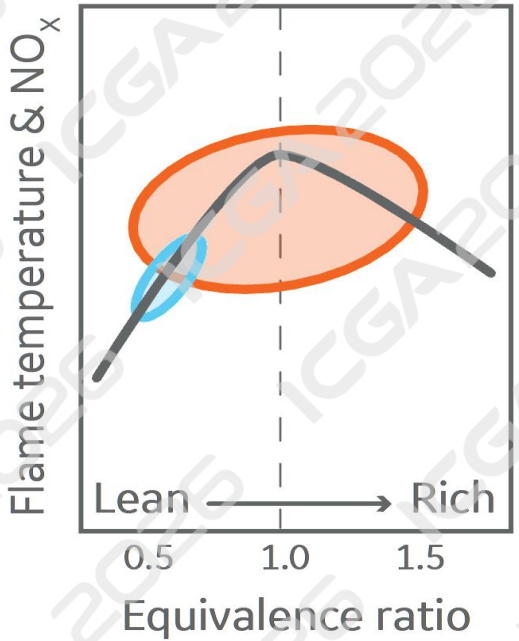
4 . R&D requirements

③ Low emission hydrogen combustion

Muti-point lean direct injection technology is the most promising method to decrease the NOx emissions of jet engines for hydrogen aviation.



Muti-point injector module



DIFFUSION FLAME

Flame characteristics

- Highly stable
- High peak flame temperature
- NO_x: ~200 to ~600 ppm

LEAN PREMIXED FLAME

Flame characteristics

- Low NO_x without diluent
- Susceptible to flashback and combustion dynamics
- NO_x: single digit ppm

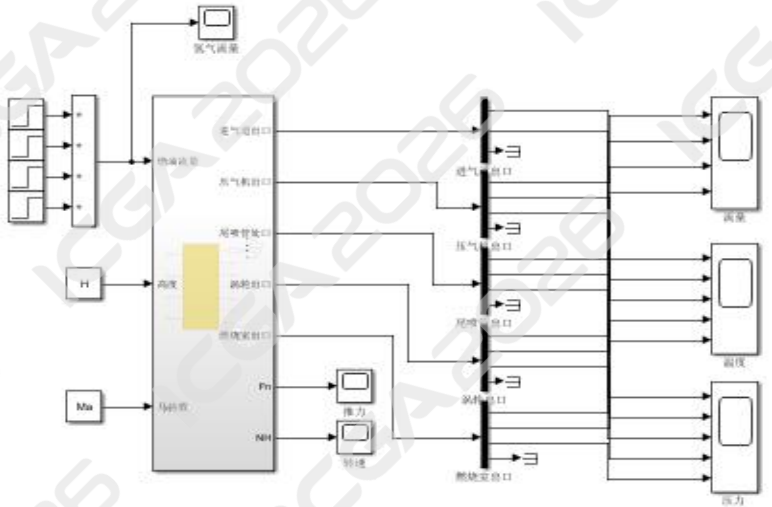
4 . R&D requirements

④ High-efficient control of hydrogen fuel

Due to the low storage temperature, high pressure, leakage, and flammability of gas/liquid hydrogen fuel, precise control of hydrogen fuel is very difficult. It is necessary to solve the problems of fuel pipeline design, pressure regulation, flow control, etc., and also need low latency , Good air tightness, high measurement accuracy, safety, etc.

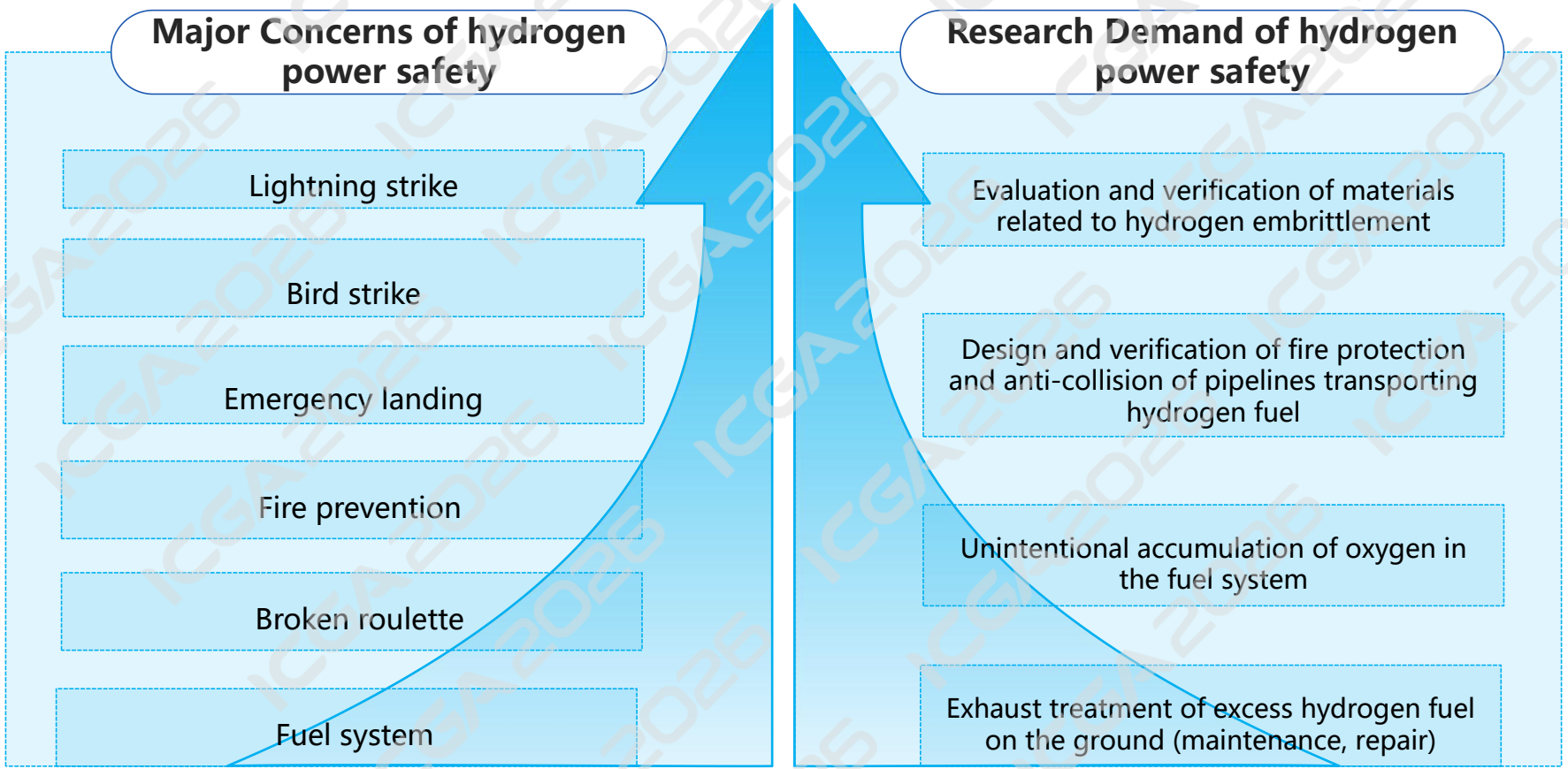
Key Technology

- Hydrogen Pressure stabilization technology
- Low-delay control technology
- Safety design for control system



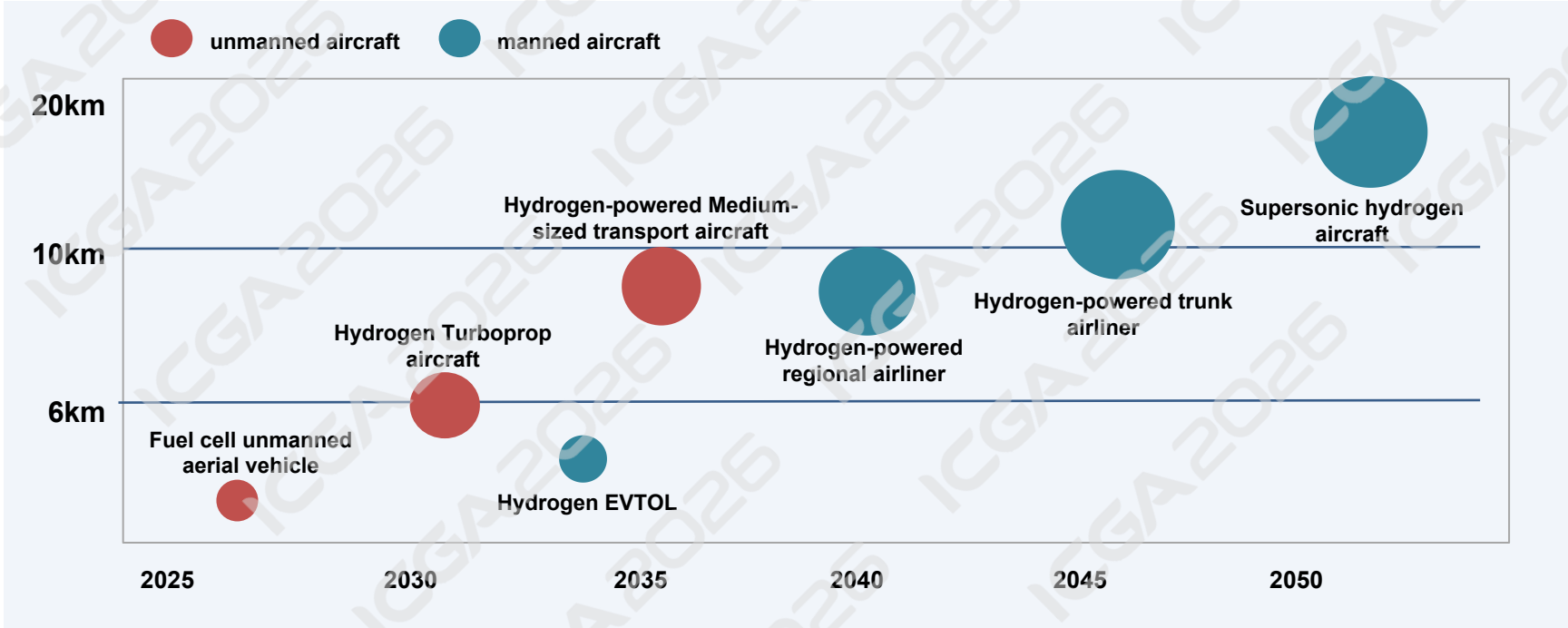
4 . R&D requirements

⑤ Airworthiness of hydrogen power



Outlook

In the future, across the spectrum from low altitude to near space, from small to large platforms, and from unmanned to manned systems, the practical application of hydrogen energy in aviation is expected to be realized after 2030–2035.



Outlook

The development of hydrogen turbine power is the key to the implementation of the dual-carbon strategy in the aviation industry, which requires collaborative research on hydrogen aircraft, hydrogen engine and hydrogen storage technology, and more importantly, close cooperation between governments, enterprises and universities. AECC Hunan Aviation Powerplant Research Institute is looking forward to working with domestic and foreign hydrogen energy enterprises and research institutes, to jointly achieve aviation carbon emission reduction and develope the international hydrogen aviation industry.

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Thanks!





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